Design & Control

Power Management Control of Electrical Propulsion Systems

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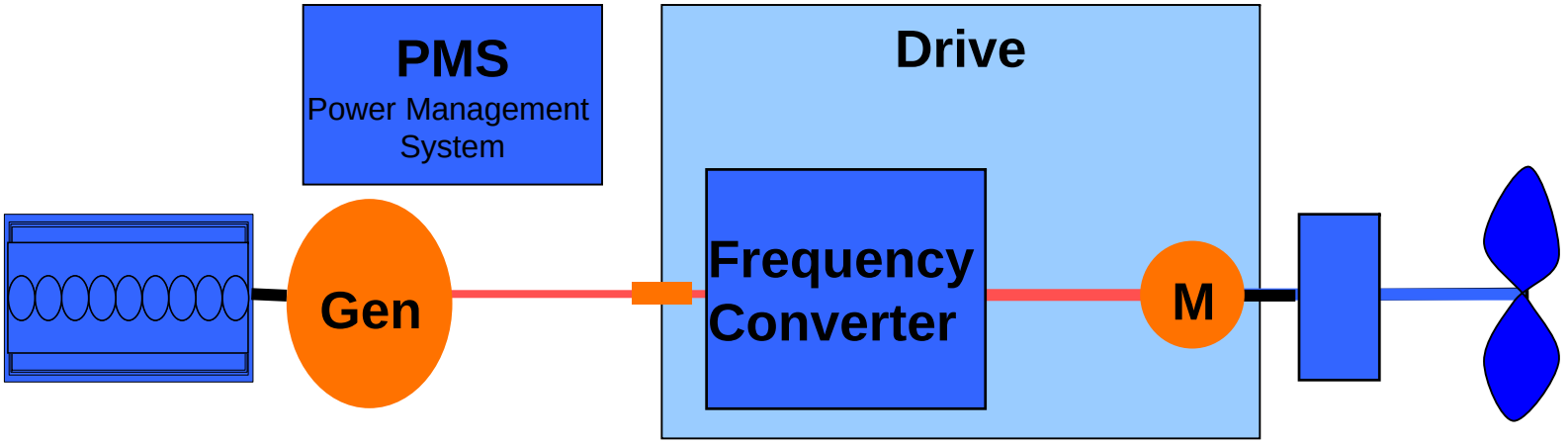
DP 2007
Power Management in Electrical Propulsion Systems

Electrical Propulsion System



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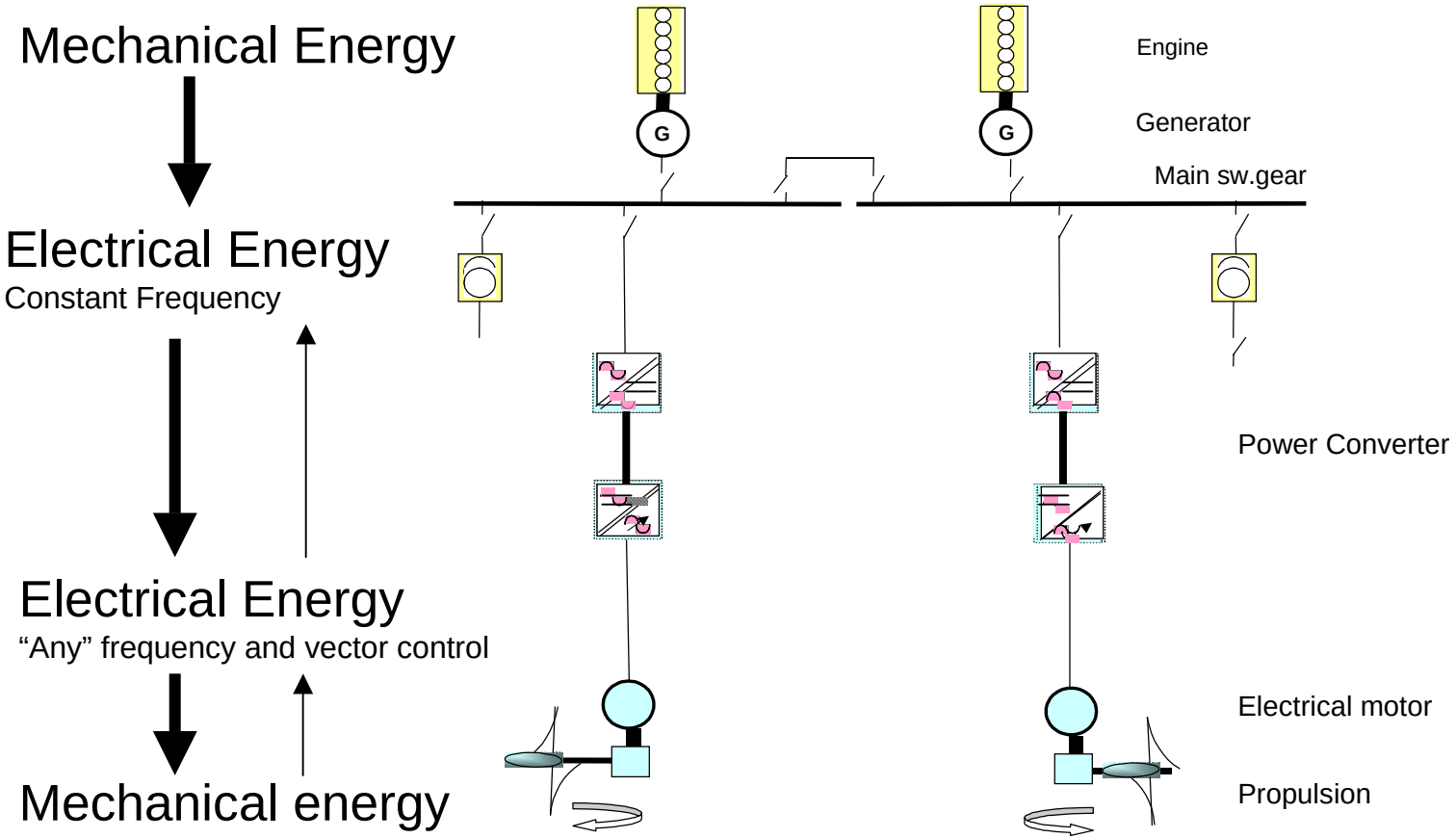
Electrical Propulsion Principle



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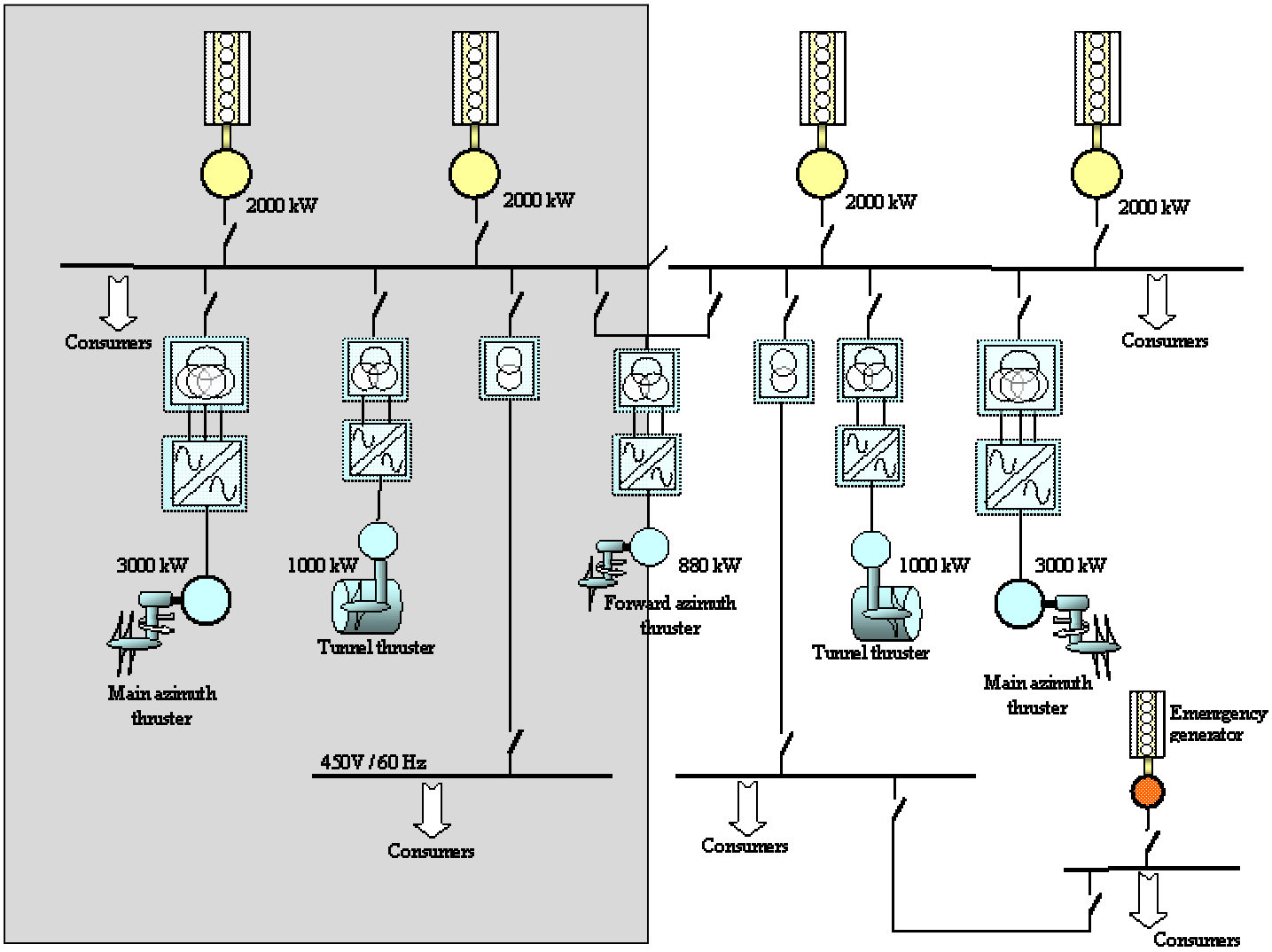
System design conventional EP system



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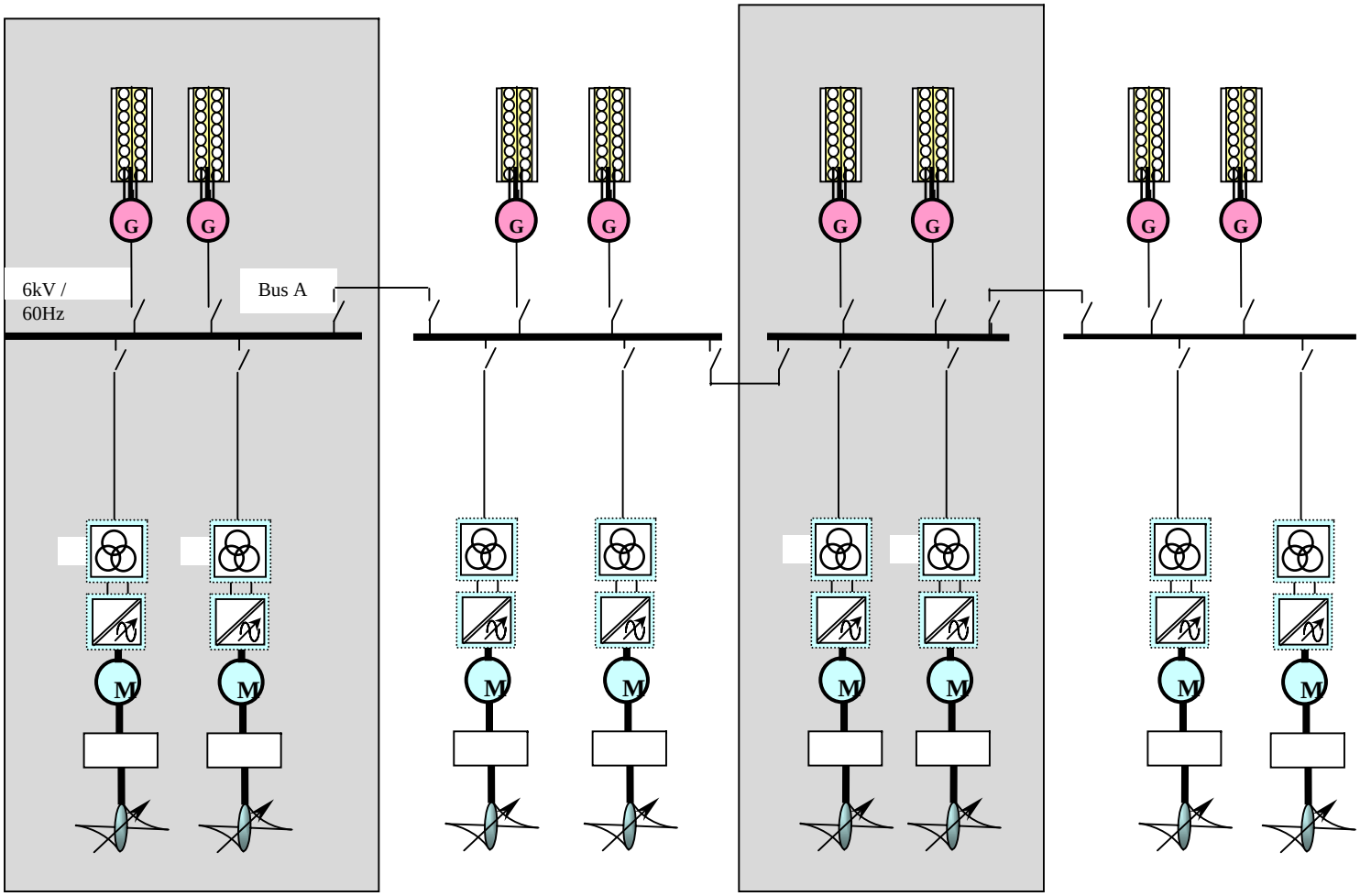
System design large electrical EP system



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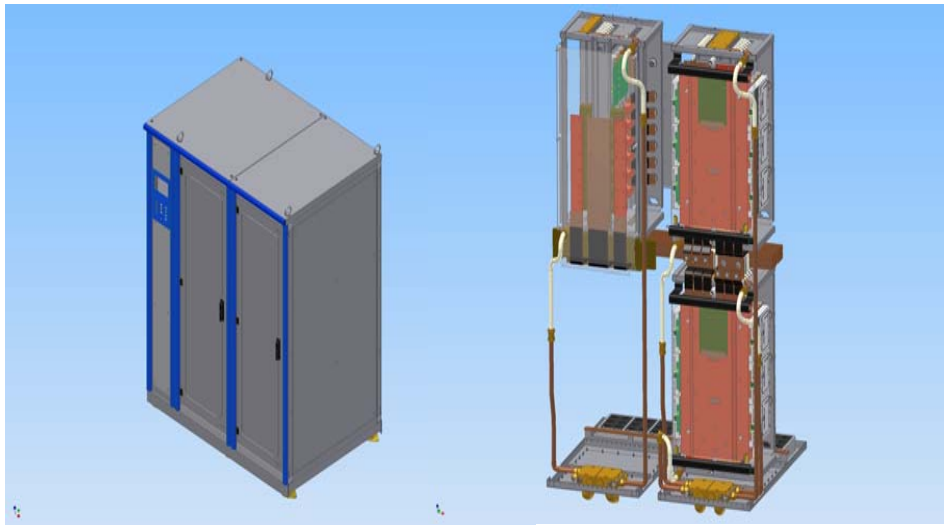
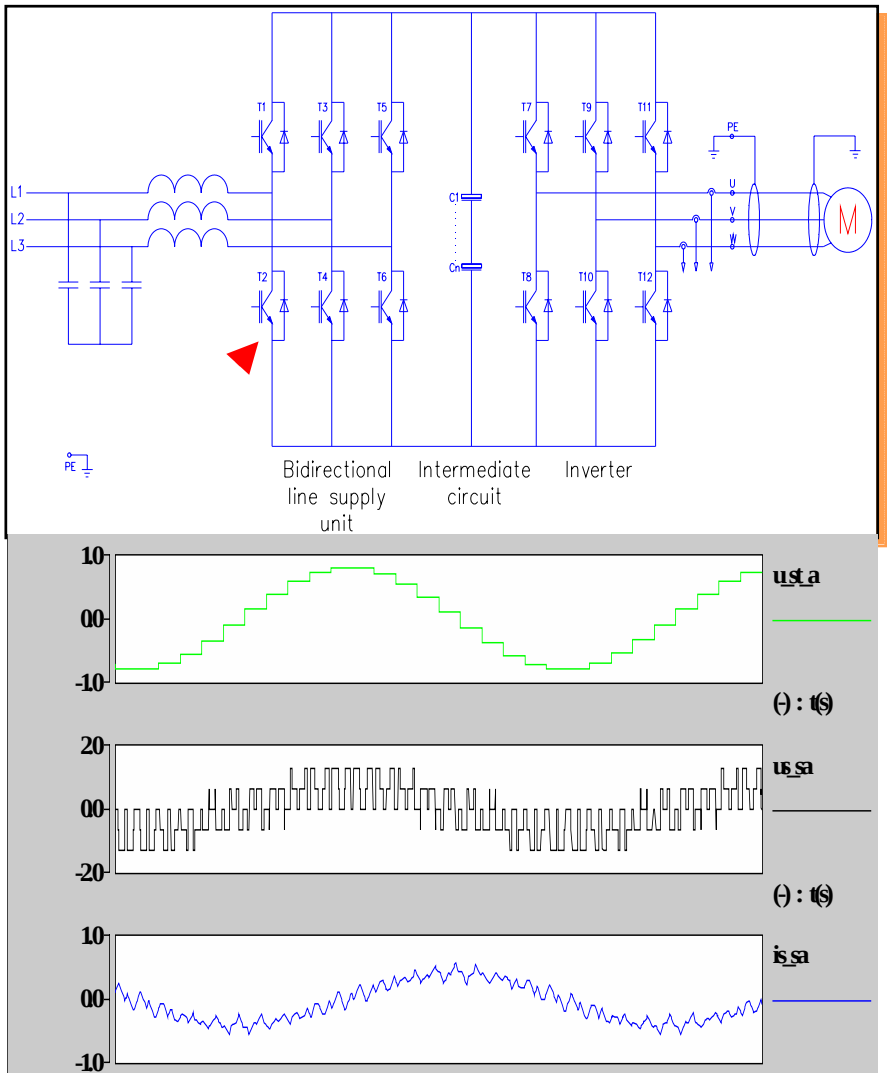
Frequency Converter





Voltage Source Inverter

Can be used for all type of electrical motors

Technology

- Insulated Gate Bipolar Transistor (IGBT)
- PWM and advanced vector control

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Rules and Requirements

- Requirement from Class (DP 2)
  - The vessel must be able to maintain the ability to keep position after worst case failures This implies that the vessel needs a redundant power supply. In case of one failure that makes the vessel dependant on one power generator (loss of redundancy) the vessel must safely terminate the operation

- Typical requirement from owner/operator
  - The vessel must be able to maintain DP 2 class, i.e. redundant power supply after worst case failures and main propulsion available.
  - This implies that the vessel needs a redundant power supply that in case of loss of one power generator can start or already have operational a third power generator that secures redundant power supply, maintaining DP 2 class.
  - Always available power for both propulsion drives may be required in critical applications

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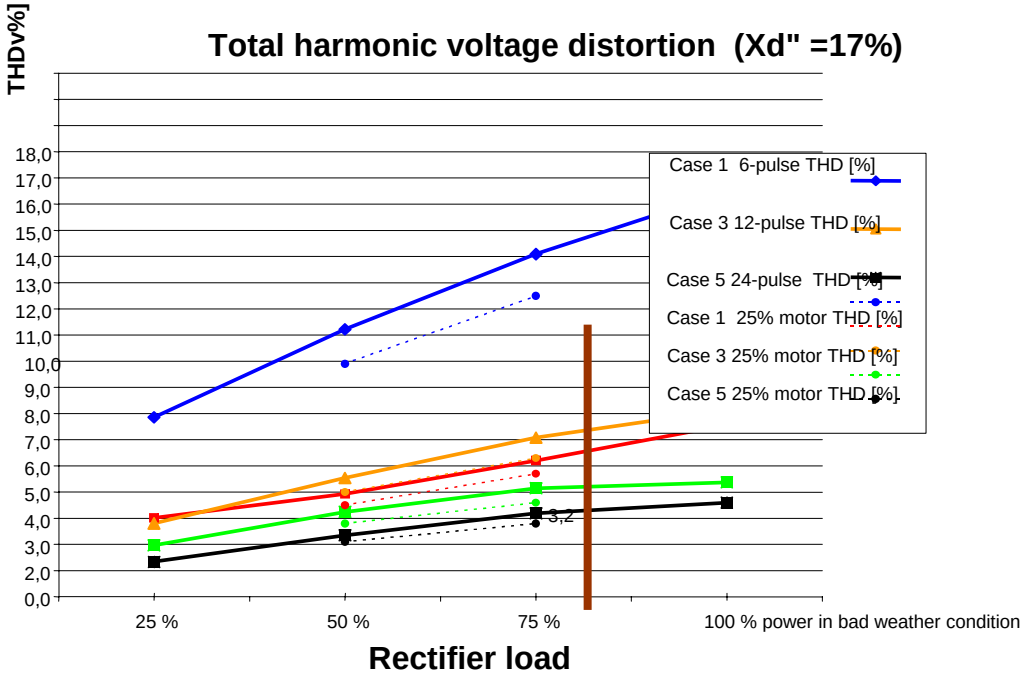
System analyses



Typical analyses and studies

-Discrimination studies
-Short circuit analyses
-Power dynamic analyses
-Load flow calculations
- Harmonic Analysis (THD)
-Safety studies
-EMC analyses
-Availability studies

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Design and responsibility

- Single responsibility
  - One supplier for the total electrical propulsion system including Power Management.
- Design review
  - HAZID
  - HAZOP
- Testing and verifications
  - SW verification based on international regulations
  - Hardware in the Loop (HIL) testing of PMS software
  - Improved factory testing and life cycle testing
- Equipment
  - Improved quality and type testing for the actual purpose
- Challenges
  - Commercial reasons
  - Class societies
  - Market drivers

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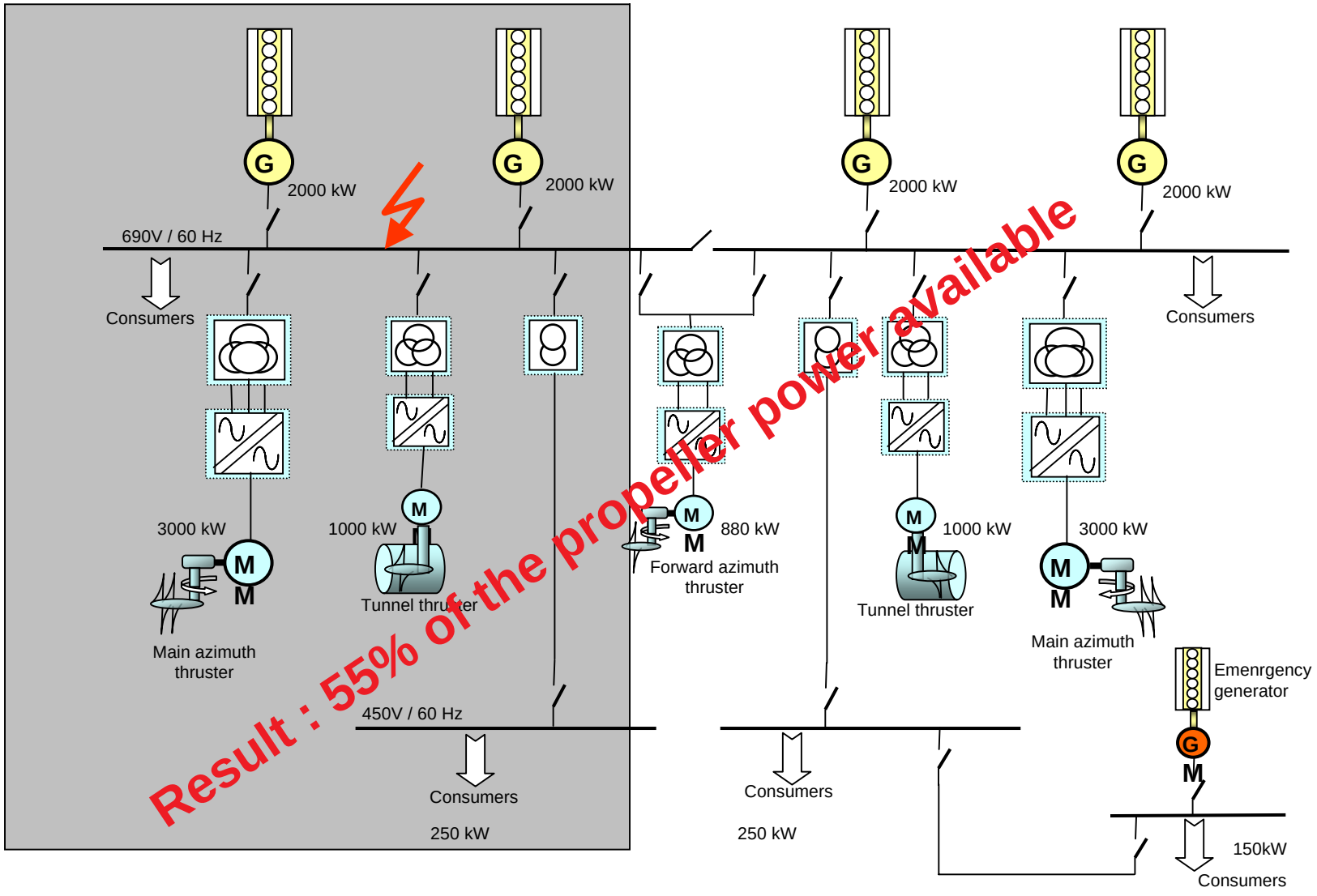
DP operated offshore vessel



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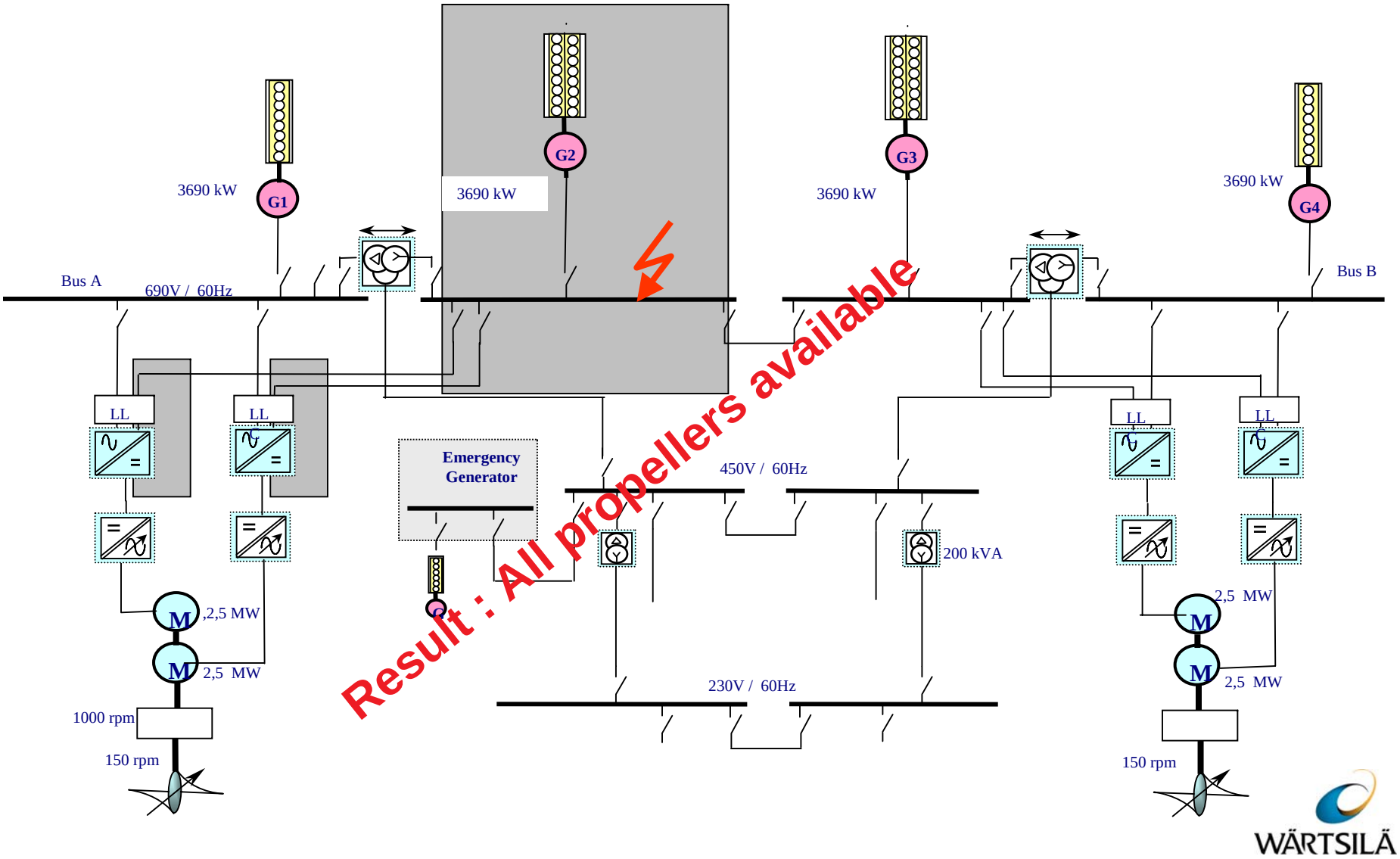
Design is important for a good energy availability



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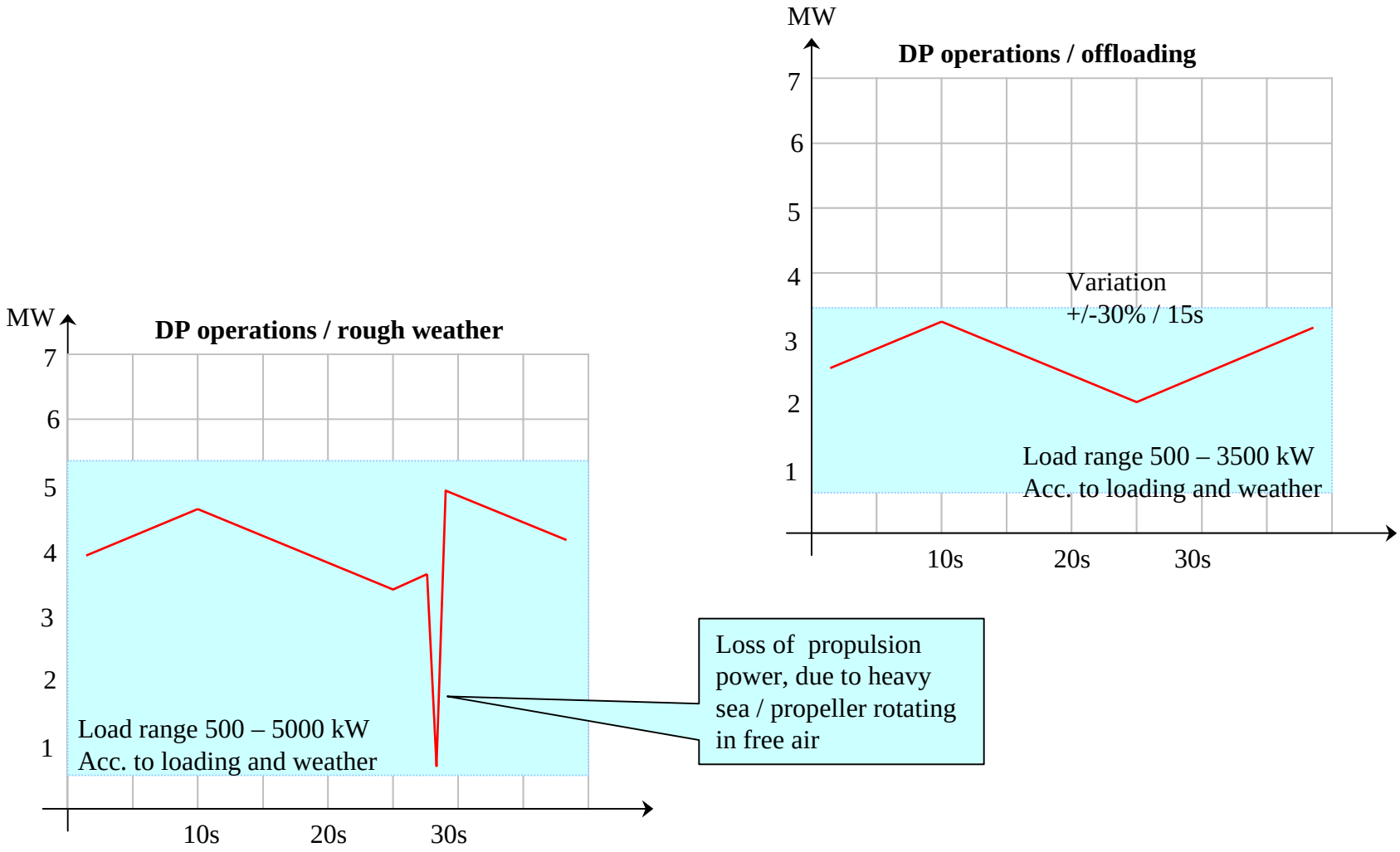
DP operation load profile



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PMS

- PMS is the sum of human experience within design and an efficient automated control and monitoring system
- PMS for propulsion should care for available power to executing required thrust in any operational condition
- Secure a safe, reliable and efficient monitoring and control of the electrical power to important vessel functions in all operational conditions.
- There are different control and management function that can be integrated as one system or separate systems
  - Power Management System(PMS)
  - Energy Management System(EMS)
  - Power and Energy Management System(PEMS)
  - Reliability Management System(RMS)
  - Integrated Platform Management System(IPMS)
  - Integrated Automation System(IAS)

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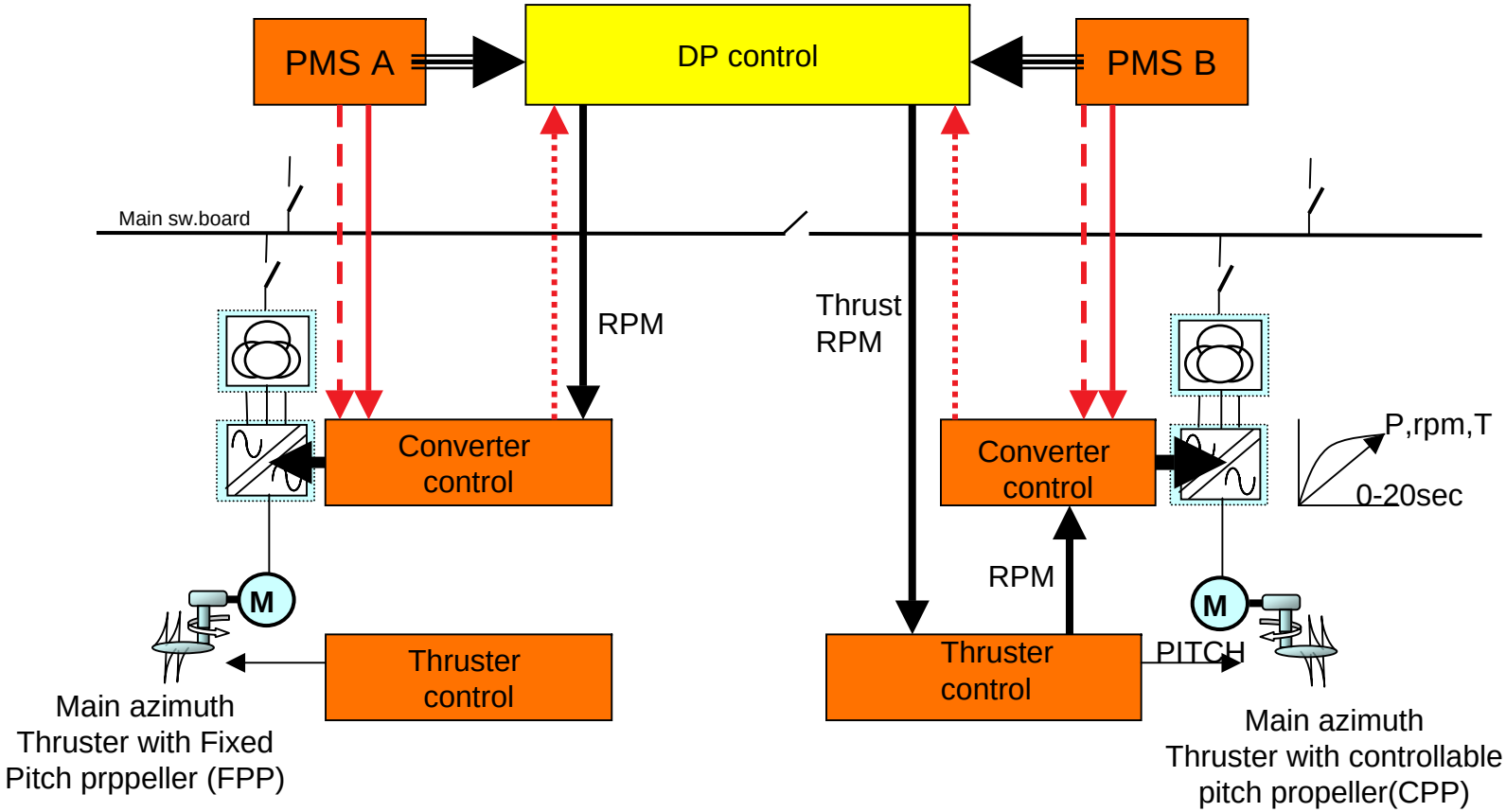
PMS

PMS A and B have same functionallity



Power Available (digital, %, dynamic)

Power Reduced (digital, % ,dynamic)

Reduce Power

Kw loading, breaker status,etc

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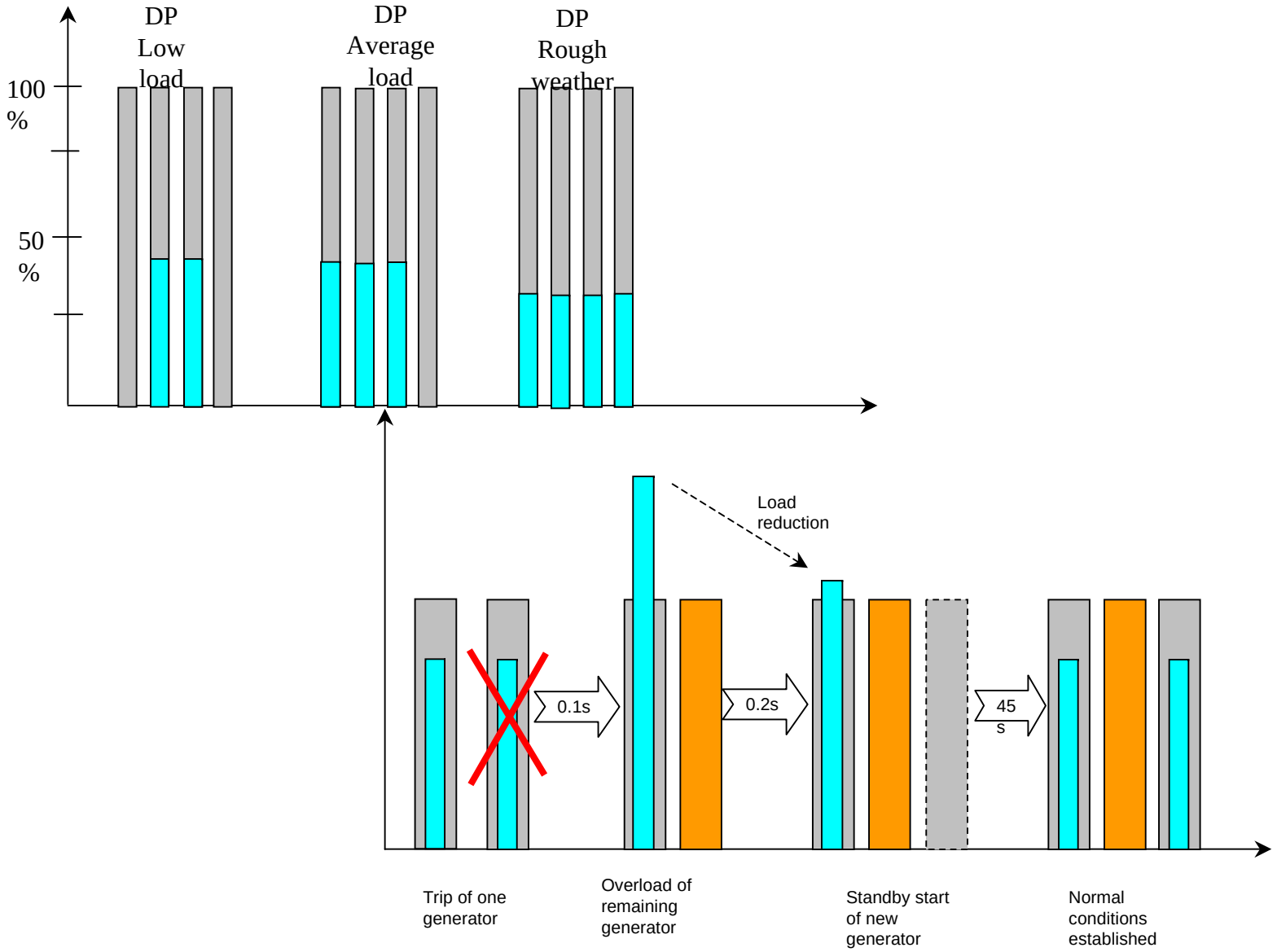
PMS during trip of generators



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PMS functions

- **Power generation management**
  - Gen-sets control
    - Automatic start and connection of engine driven generators , when trip or pre-warning of a connected gen-set has occurred.
    - Load dependent start and connections of gen-set
    - Load dependent stop and disconnections of gen-set
    - Monitoring of critical parameters.
    - Mode control
    - Max./min generators
    - Synchronization and load shearing
    - Power and voltage control
    - Active and Reactive Power Control

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PMS functions

- **Load management**
  - Available power
    - Load Control of “dynamic” consumers (Power available to bow thrusters and available power signal to propulsion converters) to prevent overload on generators
    - Transformer Control
    - Motor Control
    - Network Configuration Determination
    - Load shedding
    - Circuit breaker Control

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PMS functions

- **Dynamic blackout prevention**
  - In DP operation the PMS and frequency converter will rapidly reduce power consumption to a preset value.
  - DP system ramp up the rpm/thrust based on available power
  - In case of lack of available power eventually load shedding or other priority of thruster load will be initiated

- **Overload :**
  - load ramping rate function, based on acceptable load ramping for engines
  - overloading of thrusters based on dynamic overload curves in the converter and electrical motor and the thruster/gear/propeller
  - The signal is transmitted to the frequency converter, which reduces the load to a preset value. The execution time and load reduction time in the converter is approximately 100 milliseconds. Faster tasks may be initiated if this can be acceptable for the engines and electrical network

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Future PMS challenges

- **Multifuel strategies**
  - MDO
  - Natural gas with different methane content
  - New fuels like methanol or other bio fuels
    - New vessels will require a mixed fuel power generation with different energy content, different dynamic engine performance, different power loading and maintenance.
    - Will require a dynamic PMS setting

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Future PMS challenges

- **Environmental profiles**
  - New environmental regulations and strategies will set new standards for energy efficiency
    - Optimal use of power for thrust allocation
    - New functionality for regulation of propeller regards to ramping, anti spin functionality measuring of actual propeller thrust
    - Combined power plants –with combination of gas turbines and diesel (dual fuel) engines
    - Fuel cells
    - Power regeneration

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Future PMS challenges

- **Reliability monitoring**
  - Condition Based Maintenance(CBM) of propulsion electrical and mechanical system
    - Calculation of probability of breakdown or reduced power
    - Dynamic available power calculation

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Future PMS challenges

- **Available thrust/power always present for propeller**
  - Vessel owners require all propellers to be in operation all the time
    - Higher availability requirements specially for the electrical and control system
      - One responsible body for design
      - HAZID and HAZOP execution
      - Extensive testing and maintenance of software
      - Redundant design of power system and PMS
    - Some power better then none power
      - Modularized converters with dynamic available power (25-50-75-100%)
      - More flexible distribution concept
      - Condition based monitoring of thrusters, gears and propellers
      - Self protected converter units with dynamic loading curves

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